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As described in Section 2, Building Blocks and Scenarios, two types or levels of improvements are considered for the Sacramento–San Joaquin River Delta (Delta): “building blocks” and “trial scenarios.” The building blocks are defined as individual components of improvement that cannot be further subdivided into sub-components and still be fully functional projects. The trial scenarios represent ensembles of building blocks that offer risk reduction benefits to more than one asset or resource in the Delta and Suisun Marsh.

The building blocks were developed on the basis of the apparent and direct mitigation value they offer to the flood control system or to the resources and assets they would protect. The building blocks discussed in this report were developed along four main categories: (1) conveyance improvements, (2) protection of infrastructure systems, (3) environmental protection, and (4) flood risk reduction and life safety.

The first part of this section summarizes the key findings of the building block evaluations in terms of their risk reduction potential and costs of implementation. The second part of this section summaries the findings from the evaluation of the trial scenarios.

19.1 SUMMARY OF KEY FINDINGS OF BUILDING BLOCKS

Building Block 1.1: Improved Delta Levee Maintenance

The focus of this building block is to provide a higher level of state support for the Delta Levees Maintenance Subvention Program. The purpose is to enhance levee maintenance through more program continuity, programmatic mitigation, and an improved level of maintenance and repair of Delta levees. The primary contribution of increased Subvention Program funding would be to decrease the rate of occurrence of levee breaches from sunny-day events and at least some floods (small- and medium-sized floods).

Building Block 1.2: Upgraded Delta Levees

This building block was developed to reduce the likelihood of levee failures. The building block consists of the following sub-building blocks:

- Selected Delta levees (about 764 miles of levees) upgraded to Public Law 84-99 (PL 84-99) standards
- Selected Delta levees (about 187 miles of levees) upgraded to Urban Project Levee (UPL) standards

Most of the Delta levees already meet the Hazard Mitigation Plan standards. Some of the levees in the central Delta (called project levees) already meet the PL 84-99 standards. Upgrading levees to meet the PL 84-99 and UPL standards would reduce the flood risk and provide 100-year flood protection.

Building Block 1.3: Enhanced Emergency Preparedness/Response

The purpose of this building block is to identify potentially useful planning, organizational, and action items (e.g., stockpiling of materials, facilities construction) that can facilitate a betterorganized, more efficient, and more effective Department of Water Resources response to major flood and storm events and levee breaches in the Delta.

Enhanced emergency preparedness/response can help reduce adverse impacts from levee breach incidents. Preliminary hydrodynamic calculations and the level of stockpiling indicate that improvements in response and a reduction in export disruptions are expected. Should significant stockpiles be implemented, additional questions would be raised, such as the adequacy of equipment (e.g., barges, cranes,) to support high rates of rock placement at multiple locations during a major event.

Building Block 1.4: Pre-Flooding of Selected Islands

The purpose of pre-flooding selected islands is to reduce the risk of flooding that may cause excessive salt intrusion. Possible options for pre-flooded islands might include the following:

- After a controlled breach, allow surrounding levees to naturally degrade with wind-wave action, similar to what occurred on Franks Tract.
- Carefully design and construct breaches and armored levee interiors to preserve the levees and control tidal flow in and around the flooded islands.
- Armor and preserve the surrounding levees and use the flooded islands as in-Delta reservoirs, similar to the proposed Delta wetlands project.

In all three cases, the islands would be filled during periods of high runoff to minimize potential salinity intrusion impacts.

Pre-flooding sets of Delta islands would reduce the disruption of Delta water exports and the resulting export deficit with large-scale levee failure events. The most promising option appears to be selecting sets of islands in the south Delta and leaving those islands closed to tidal exchange. Key findings include:

- The western Delta islands should not be breached and left open to tidal exchange due to the resulting increase in dispersive salt flux into the central Delta.
- Pre-flooding eastern Delta islands and leaving them open to tidal exchange does not appear to have a negative salinity impact. This result is likely to be true for north Delta islands as well.
- Hardening Delta islands against failure or pre-flooding and leaving the islands closed to tidal exchange may in general be a more robust solution because breached islands may accumulate salt if the period following a failure event is very dry.

Pre-flooding and closing the islands may require management that could include levee maintenance.

Building Block 1.5: Land Use Changes to Reduce Island Subsidence

This building block considers constructing wetlands on Delta peat islands. Carbon sequestration has been shown to successfully reverse subsidence and result in a net accretion of organic carbon over time. However, little is known about how this accretion would change the indirect risks associated with catastrophic levee breach over time. Key findings include the following:

- Wetlands can be used to reverse subsidence on Delta peat islands where ponding depth and plant species are optimized.
- U.S. Geological Survey work suggests that optimal water depths are 1 to 2 feet to maximize carbon sequestration and accumulation of organic matter. The elevation of Delta islands typically varies by considerably more than 2 feet. Therefore, a substantial amount of grading would be required to reduce this variability across an entire island's surface.
- Construction costs can be reduced by changing land use practices and allowing islands to naturally level over time or alternatively by using natural island contours to achieve optimal ponding depths on separate island segments.
- The benefits of carbon sequestration include improved biodiversity, subsidence reversal, and reduction in greenhouse gases.
- The constraints to carbon sequestration include the loss of agricultural production on islands and increased costs to protect infrastructure.
- Reductions in the direct and indirect risks associated with a catastrophic levee breach include reduced on-island economic consequences in the event of levee failure, and reduced salinity intrusion due to a reduced island volume in the future. Given that the benefits of carbon sequestration would be increasingly realized through time, the temporal elements of this risk reduction need to be quantified. Available data indicate that the overall rate of accretion can be estimated at 2.6 inches per year or nearly 11 feet in 50 years. Considerable social and transaction costs are likely to be involved with any carbon sequestration project. These costs, whether compensation for lost agricultural production or capital costs to purchase land, have not been assessed as part of this cost estimate.

Building Block 1.6: Armored "Pathway" (Through-Delta Conveyance)

A significant quantity of freshwater enters the Delta annually from the Sacramento River (approximately 21 million acre-feet). Currently, most Sacramento River flows are discharged to San Francisco Bay. The armored pathway (Through-Delta Conveyance) building block was developed to move freshwater from the Sacramento River to the State Water Project and Central Valley Project intake facilities located in the south Delta in case of a major disruption to water quality due to multiple island failures. The armored pathway building block consists of six main components:

- Intake facilities and fish screens on the Sacramento River near Hood
- Dredging of the alignment
- Two minor bridges
- Seismic-resistant setback levees along the alignment
- Restoration of riparian corridor and shaded riverine aquatic habitat along about 110 miles of the water's edge in the through-Delta conveyance
- Salinity barrier gates to control flow during major disruption caused by multiple levee failures, to allow freshwater conveyance to the export pumps

The through-Delta conveyance would provide a relatively more reliable water export system than present conditions and would add more habitat along about 110 miles water's edge.

Building Block 1.7: Isolated Conveyance Facility Alternatives

The Isolated Conveyance Facility (ICF) would provide a north-to-south freshwater corridor through the construction of an isolated canal around the eastern periphery of the Delta. The ICF would include the following components:

- Intake structures and fish screens near Hood
- Canal excavation and embankment construction to the elevation of mean higher high water plus 3 feet
- Road and railroad bridge crossings
- Siphons under sloughs and flow-control structures
- Pumping station at Disappointment Slough

The ICF would significantly reduce the vulnerability of water export to Delta levee failure and flooding. The ICF could also be operated to improve water quality during major failures of the Delta levees.

The canal embankments are conceived to resist a 200-year earthquake. The canal embankments would be constructed with 3 feet of freeboard above MHH. Although the canal would be overtopped by large flood events (e.g., a 100-year flood), such flooding would result in freshwater entering the canal and thus would not pose water quality issues. After such a large flood event, the canal embankments would need to be repaired.

Building Block 1.8: San Joaquin Bypass

The purpose of this building block is to evaluate two alternative flood bypasses or equivalent plans for Stewart Tract and Roberts Island. The objectives are twofold: (1) protect lives and property in Lathrop, Mossdale, Stockton, and adjacent communities during flood events, and (2) create more habitat for fish, waterfowl, and wildlife, and improved aquatic food-web production and water quality, as described in the Bay-Delta Ecosystem Restoration Program Plan (CALFED ERP 2007).

Two alternatives were considered under this building block:

- Alternative 1: Construct weirs to divert San Joaquin River floodflows through Stewart Tract and Roberts Island and thereby lower water surface elevations adjacent to populated areas on the east river bank.
- Alternative 2: Widen the San Joaquin River flood channel by removing the west bank levee and constructing a new setback levee along the eastern edge of Stewart Tract and Roberts Island. Create permanent floodplain habitat in the 22-mile-long, half-mile-wide area between the river and new setback levee.

Construction of either Alternative 1 or Alternative 2 would result in a decrease in the water-surface elevations in San Joaquin River between Lathrop and Stockton. The decrease for a large storm event could be on the order of 10 feet in the vicinity of Mossdale and 3 to 5 feet along the western edge of Rough and Ready Island.

A reduction in the peak water surface elevations of the order predicted in this analysis corresponds to a factor of 10 or more reduction in the frequency of levee failures along San Joaquin River between the south end of Stewart Tract and Rough and Ready Island. Besides providing increased flood protection to towns along the San Joaquin, a significant risk reduction would occur for islands in the Delta.

Both alternatives would provide substantial flood control to the populated areas east of San Joaquin River. Alternative 2 provides more benefits and fewer adverse effects to social systems, agricultural land use, infrastructure, land value, and habitat than Alternative 1. Alternative 2 also provides improved flood protection to the majority of Stewart Tract and Roberts Island.

Building Block 2.1: Raise State Highways

Raising State Route (SR) 4, SR 12, and SR 160 above the Federal Emergency Management Agency (FEMA) 100-year flood elevation and constructing them on piers with a seismically resistant design could reduce the risk of damage and failure for those highways. Also, this building block has the benefit of having the roads in service in the event of a seismic- or flood-induce levee failures.

Raising SR 4, SR 12, and SR 160 would require significant capital cost, and would outweigh the direct risk reduction benefits. However, if a significant portion of the levees were breached, the state highways would be an access route for emergency repairs and normal uses. The loss of these highways during the emergency period would result in delays in repairing damaged levees and increase economic costs.

Building Block 2.2: Construct Armored Infrastructure Corridor Across Central Delta

To reduce the risk of the loss of essential infrastructure due to flooding or seismic activity, this building block evaluates the construction of an armored corridor with new levees. The new levees would be seismically resistant and have elevations 3 feet above the 100-year FEMA flood elevation. Two options for the placement of the relocated infrastructure were considered:

- Option 1: Construct two east-west levees, a northern and southern levee, across the central Delta. Construct SR 4 on the new southern levee and the BNSF railroad on the new northern levee. The existing Mokelumne Aqueduct system and the Kinder Morgan pipeline would be unaffected but protected against flood or seismic failure of the Delta levees.
- Option 2: Construct a single, larger levee to the south of the Mokelumne Aqueduct system. This new levee would carry the new SR 4, the BNSF railroad, the Mokelumne Aqueduct system, and the Kinder Morgan pipeline.

The main risk-reduction benefit of this building block would be the improved reliability of the transportation system, the railroad, water supply delivery via the Mokelumne Aqueduct system, and product delivery via the Kinder Morgan pipeline. The risk-reduction benefits appear to outweigh the cost. It is noted that this building block is similar to strategy that the East Bay Municipal Utility District (EBMUD) is employing to protect the aqueduct system.

Building Block 3.1: Suisun Marsh Tidal Wetland Restoration and Managed Wetland Enhancements

The purpose of this building block is habitat enhancement and protection of existing wetland and wildlife resources, values, and functions. Its main purpose is not risk reduction, though some risk is mitigated. This building block evaluates the benefits associated with tidal marsh restoration and managed wetland enhancement as well as the conceptual-level costs and reduction of risks. The key finding of the analysis of restoring tidal wetlands in Suisun Marsh is that there are island complexes where restoration is most cost-effective.

Considerable potential exists to enhance and diversify Suisun Marsh habitats and contribute to the recovery of special-status species. However, this opportunity may be accompanied by the loss of diked managed wetland habitats, wildlife populations, hunting areas, and significant impact to water quality from increased mixing of salts. Levees that are breached and lands that are restored to tidal action reduce the risk of catastrophic levee failure and repair costs.

Building Block 3.2: Tidal Marsh Cache Slough Restoration

The purpose of this building block is to create a conceptual preservation, restoration, and implementation plan for the Cache Slough Complex to restore the ecology of the region. This plan is based on a conceptual analysis of proposed general and specific habitat restoration goals presented in a collection of plans by various agencies (Solano Land Trust, Bay-Delta Conservation Plan, Public Policy Institute of California, North Delta National Wildlife Refuge, Pacific Flyway and Central Valley Joint Venture, and Office of the Governor of California).

The study area includes the Cache Slough Complex below the 100-year floodplain that is bordered in the northeast by the Yolo Bypass, including some portion of the bypass area, and Prospect Island on the west. The analysis presents a rough estimate of the acreage of habitat and listed species that would benefit from the hypothetical removal of the barriers separating wetland and upland habitat.

Conservation and restoration of 32,900 acres would connect with 12,000 acres of currently conserved or restored areas, increasing contiguous habitat by 37 percent to 44,900 acres. Conservation groups with similar goals may be interested in coordinating efforts to protect and restore the area. This area would protect sensitive habitats supporting high levels of biodiversity, including riparian and vernal pool habitat, which support over 80 listed species. Tidal restoration of this area would initially re-establish 23,600 acres of floodplain, 7,100 acres of rapidly establishing tidal marsh, 3,900 acres of tidal marsh that would establish slowly over time, and 10,300 acres of open water habitat. Restoration would connect wetland and upland habitats over this large area, which is critical to several listed species. Some of the restoration actions proposed here may also benefit exotic fish species. The habitat value of restored floodplain is directly connected with the operations of the Yolo Bypass, and in particular the frequency of flooding.

Analysis of fish surveys indicates that little is known about preferred Delta smelt spawning microhabitat or locations. Several lines of data suggest that they may spawn in shallow water gravel areas near deep water and may use the Sacramento Deep Water Ship Channel and benefit from restored areas of deep water near tidal marsh. Further data collection would be required to determine actions that would increase Delta smelt spawning and rearing habitat.

Building Block 3.3: Install Fish Screens

The purpose of this building block is to provide a conceptual overview of possible fish screens in the Delta and to provide a general assessment of their function based on our current understanding of how they may be designed. Fish screens were reviewed for the ICF, the Tracy Pumping Plant, the Banks Pumping Plant, and small agricultural withdrawals. The following are the key findings of this building block:

- No effective, proven means exist to physically screen eggs and larval life stages of fish from intakes.
- Screens that operate in the Delta to the current criteria for Delta smelt are effective at excluding larval life stages (fish smaller than 25 millimeters in length) from small intakes. However, at the large Tracy and the Banks Pumping Plant intakes, the fish survival benefits of collecting, transporting, and releasing these small fish is uncertain.
- The intakes at the Isolated Conveyance Facility, Tracy Pumping Plant, and Banks Pumping Plant require large facilities to screen flows from 4,000 cubic feet per second (cfs) to 15,000 cfs. These large flows can be successfully screened using multiple in-canal vee-type screens of about 2,500 cfs capacity in each module. Screens of this size have been used successfully at other installations, such as the Skinner Fish Facility.
- The possible biological benefits of screening intakes in the Delta are not clearly known because many factors can influence the overall benefit. Reductions in direct fish losses could be significant because fish entrainment and impingement losses at the screens would approach zero for fish over 20 millimeters.
- The south Delta fish screens will not be as effective at protecting fish as those located in the north Delta or at an Isolated Conveyance Facility intake for several reasons. First, a greater amount of debris must be removed by mechanical means in the south Delta, which will affect fish survival. Second, the fish bypassed in the screening facility must be transported to another location in the Delta. This operation increases the stress on and the mortality of the fish. Third, facilities in the south Delta is more likely to entrain smaller fish that cannot be effectively screened. Fourth, the poor water circulation in the south Delta makes the intake more vulnerable to extended outages due to fish being trapped in a dead-end area.
- The south Delta screening facility will cost more than similarly sized facilities in the north Delta for at least four reasons. First, poor subsurface soil conditions will require more costly foundations. Second, additional structure and mechanical devices will be required to remove the additional accumulated debris from the water. Third, the bypassed fish require holding facilities and it will be necessary to provide a means to transfer fish to release sites throughout the Delta. Fourth, the tidal influences and shallow water depths could require a larger facility than is required in the north Delta.
- Over 2,000 agricultural withdrawal sites are present in the Delta, and only 1 percent of them are currently screened.

The Delta is a complex and unique environment with multiple competing interests and resources. These relationships and balances have been studied for some time, but it is still unclear what the benefits or impacts are for the actions discussed under this building block. Despite this uncertainty, fish screening does reduce some risk of fish loss for a given diversion and is therefore likely to be a part of any future Delta actions.

Building Block 3.4: Setback Levee to Restore Shaded Riverine Habitat

The setback levee building block was developed to restore shaded riverine habitat and to reduce the likelihood of levee failures due to seismic events. This building block consists of sub-blocks for 20 or 30 miles of setback levees to withstand a 200-year earthquake.

Seismically upgrading Delta islands to the setback design may reduce the frequency of individual island failure. Also, setback levees would create riparian corridors and shaded riverine aquatic habitat.

Building Block 3.6: Reduce Water Exports from the Delta

The purpose of this building block is to begin exploring changes that would be involved in reducing Delta water exports. The objective is to provide an initial understanding of what it would mean if Delta water exports were decreased. Three alternative levels of decreased water exports were considered: 10 percent, 25 percent, and 40 percent.

The key findings of the exploratory analysis are the following:

- Responses and impacts to stipulated reductions in Delta water exports are complex and uncertain. Even preliminary characterizations require more detailed and intensive analyses than have been possible within the Delta Risk Management Strategy (DRMS) Phase 2 schedule.
- Responses and impacts in the context of normal conditions (no levee breaches) are expected to be nonlinear; they will increase more dramatically, especially in capital and operating cost, as the size of the export reduction is increased. Exported water will transfer from agriculture to urban agencies, groundwater will be increasingly developed and overdrafted and agricultural land fallowing will occur. To the extent that fish are now adversely impacted by diversion of Delta waters and entrainment in the south Delta pumps, they should be less impacted, and the surviving species should be more viable.
- Risk reductions are extremely uncertain and are likely to be variable.
  - For urban agencies, to the extent that a percentage of their supply comes from Delta exports, one might expect them to be impacted by the disruption due to a major levee breach event. The impacts to urban agencies could be greater, depending on their conservation efforts, the availability of emergency supplies, and the type of water years (drought years versus wet years).
  - For agricultural water users, a Delta levee breach event is likely to have much more dramatic effects, even though substantial acreage has been fallowed. Groundwater basins are likely to be severely overdrawn in agricultural areas and unavailable as significant emergency supplies. More acres of high-value, permanent crops are likely to be lost.
  - For aquatic organisms, the only chance for reduced Delta exports to provide an improved outcome to a major levee breach event is to have a more viable aquatic ecosystem when the event occurs. Entrainment onto flooding islands and other adverse mechanisms are

still likely to produce very high mortalities. Only the advantage of having a larger and stronger population at the beginning of the event might lead to a larger number of survivors. This strength may give the species an ability to regenerate a sustainable population. In contrast, some species populations may be so marginal that they could be lost under “business as usual”.

The choices, relationships, and interactions necessary to characterize the results of decreases in Delta exports are complex. Assessment of risk reduction benefits (in the face of Delta levee breaches) requires another step to extend the analyses beyond “normal conditions,” which are already uncertain and have received limited study. More intensive analysis is required if quantitative estimates of the results are desired.

19.2 EVALUATION OF BUILDING BLOCKS

As stated above, the building blocks discussed in this report were developed along four main categories consisting of: (1) conveyance improvement, (2) protection of infrastructure systems, (3) environmental protection, and (4) flood risk reduction and life safety. The evaluation of the building blocks is discussed along these four main categories. For each of the building blocks, a summary of the relative risk reduction benefits, overall risk reduction (in-Delta, ecosystem, and economic) and cost to implement are discussed. In the evaluation of building blocks that follows, we consider the relative overall risk reduction and the cost of implementation.

Flood Risk Reduction and Life Safety (Building Blocks 1.1 to 1.5 and 1.8)

Although improved levee maintenance and enhanced emergency preparedness have low implementation costs, they provide moderate reduction in risk. For improving Delta levees to PL 84-99 and UPL standards, the costs of implementation are high to very high, but they afford a low to moderate risk reduction against flood hazards. These building blocks do not provide a reduction in the seismic risk.

Conveyance (Building Blocks 1.6 and 1.7)

The highest overall reduction to the risk of water export disruption is the ICF, followed by the dual conveyance (DC) (ICF and armored pathway), then the through-Delta conveyance (TDC). Although the costs of implementation are high, the loss reductions (benefits) are much higher than the cost of implementation (costs). The ICF, DC and TDC building blocks would increase the reliability of water delivery and improve water quality in that order.

Infrastructure Risk Reduction (Building Blocks 2.1 and 2.2)

The two building blocks considered in this category have a high overall risk reduction and high to very high relative cost. However, the combined contribution with other building blocks may make them attractive.

Environmental Risk Mitigation (Building Blocks 3.1 to 3.5)

The building blocks in this category provide benefits through enhanced and additional habitat and ecosystem restoration. Most of the building blocks have low to moderate implementation costs, particularly when combined with others (e.g., TDC, San Joaquin Bypass). The benefits are estimated to by high to very high.

19.3 SUMMARY OF KEY FINDINGS OF THE TRIAL SCENARIOS

The following discussion summarizes the key findings for each of the trial scenarios evaluated. A qualitative summary of the trial scenarios in terms of the relative risk-reduction benefits (levee failure and in-Delta costs, ecosystem consequences, and economic consequences), overall risk reduction, and the cost of implementation follows.

Trial Scenario 1: Improved Levees

The purpose of this scenario is to improve the reliability of Delta levees against flood-induced failures. In this scenario, central Delta island levees are upgraded to PL 84-99 standards and urban areas are upgraded to UPL standards. This upgrade improves the reliability of the levee system up to 100-year flood protection, but offers no risk reduction benefits for seismic events.

Other major components of this trial scenario include improvements to transportation and utility corridors, consisting of raised highways and construction of an armored infrastructure corridor. These improvements provide both seismic and flood risk reductions.

Other highlights of this scenario include enhanced emergency preparedness and a number of environmental restoration actions.

The findings of the evaluation of this scenario include:

- The scenario results in a moderate reduction to the risk of flood-induced failures and does not change the seismic risk of levee failure.
- A moderate reduction in the risk of levee failures due to flood events occurs in this scenario, but the scenario does not provide any reduction to the seismic risk of levee failure.
- No risk reduction is apparent with regard to potential water export interruption.
- Improvements in levee maintenance and overall emergency preparedness have a positive but limited impact on risk reduction.
- A clear benefit results from restoration and improvement of the ecosystem in the Delta; a substantial addition of habitat space fosters bio-diversity.
- Land-use change does not have a direct benefit to current or near-term risk of levee failures; however, it is anticipated that a reduction in subsidence offers longer-term benefits by reducing the future accommodation space.
- The general cost of implementation for this trial scenario is about $10.5 billion, and the cost benefit for a 50-year life cycle is about $69 billion (see Table 18-6 for other life-cycle cost benefits and impacts).

Scenario 2: Armored Pathway(Through-Delta Conveyance)

The purpose of this scenario is to improve the reliability of water conveyance by creating a route through the Delta that has high reliability and the ability to mitigate the intrusion of saltwater into the south Delta. The armored pathway is created by seismically upgrading the levees along a pathway from the Sacramento River near Hood to the pumps in the south Delta (see the description of Building Block 1.6), dredging channels to provide the required capacity, and installing channel barriers in the south Delta to limit saltwater intrusion during multiple island-flooding events. This scenario also provides for infrastructure improvement (raising highways, developing an armored infrastructure corridor), levee upgrade to PL 84-99 and urban levee standards, and environmental improvements and restoration.

The findings of the evaluation of this scenario include:

- The armored pathway reduces the likelihood of levee failures that could impact water exports. This upgrade, coupled with the installation of barrier gates in the southern Delta, has the joint benefit of significantly reducing the likelihood of export disruptions.
- The scenario provides a moderate reduction to the risk of levee failures due to flood events but provides no reduction to the seismic risk of levee failure.
- The scenario provides a substantial risk reduction to the potential costs and impacts associated with transportation and utility interruption due to both flood and seismic events.
- Improvements in levee maintenance and emergency preparedness overall have a positive, but limited impact in terms of risk reduction.
- A clear benefit results from restoration of and improvements to the ecosystem in the Delta, and the substantial addition of habitat spaces fosters bio-diversity.
- Land-use change does not have a direct benefit to the current or near-term risk due to levee failures; however, it is anticipated a reduction in subsidence offers longer term benefits by reducing the future accommodation space.
- The general cost of implementation of this scenario is about $15.6 billion, and the cost benefit for a 50-year life cycle is about $71 billion (see Table 18-6 for other life-cycle cost benefits and impacts).

Scenario 3: Isolated Conveyance Facility

The purpose of this scenario to is to provide high reliability for water conveyance (up to 15,000 cfs) by construction of an ICF on the eastern side of the Delta (see the description of Building Block 1.7). The ICF avoids the vulnerability of water export disruptions associated with levee failures. This scenario also provides for infrastructure improvement (raising highways), improved maintenance and emergency planning, levee upgrades to PL 84-99 and urban levee standards, and environmental improvements and restoration.

The findings of the evaluation of this scenario include:

- The ICF avoids the vulnerability of water exports associated with Delta levee vulnerability and thus offers significant flood and seismic risk reduction over present conditions. The ICF, coupled with the installation of barrier gates in the south Delta, has the benefit of reducing the likelihood of significant export disruptions.
- The scenario provides a moderate reduction to the risk of levee failures due to flood events, but the scenario provides no reduction to the seismic risk of levee failure.

- A substantial risk reduction results because of the potential costs and impacts associated with transportation and utility interruption due to both flood and seismic events.
- Improvements in levee maintenance and emergency preparedness have an overall positive, but limited impact in terms of risk reduction.
- A clear benefit results from the restoration of and improvement to the ecosystem in the Delta, and the substantial addition of habitat space fosters bio-diversity.
- Land-use change does not have a direct benefit on the current or near-term risk due to levee failures; however, it is anticipated a reduction in subsidence offers longer term benefits by reducing the future accommodation space.
- The general cost of implementation this scenario is about $14.8 billion, and the cost benefit for a 50-year life cycle is about $83 billion (see Table 18-6 for other life-cycle cost benefits and impacts).

Scenario 4: Dual Conveyance

The purpose of this scenario to is to provide higher reliability and flexibility for water conveyance by construction of an ICF on the eastern side of the Delta (similar to Trial Scenario 3) and a through-Delta conveyance (similar to Trial Scenario 2). The scenario also provides levee improvements, enhanced maintenance and emergency planning, improvements to transportation and utility lines, environmental restorations similar to the previous scenarios.

The findings of the evaluation of this scenario include:

- The DC scenario avoids the vulnerability of water exports associated with Delta levee vulnerability and thus offers significant flood and seismic risk reduction over the present condition. The DC also has the benefit of flexible water export from the Delta and/or from the ICF.
- The scenario provides a moderate reduction to the risk of levee failures due to flood events but provides no reduction to the seismic risk of levee failure.
- The scenario provides substantial risk reduction to the potential costs and impacts associated with transportation and utility interruption due to both flood and seismic events.
- Improvements in levee maintenance and emergency preparedness have an overall positive, but limited impact in terms of risk reduction.
- A clear benefit results from restoration of and improvements to the ecosystem in the Delta, and the substantial addition of habitat spaces fosters bio-diversity.
- Land-use change does not have a direct benefit to the current or near-term risk due to levee failures; however, it is anticipated that a reduction in subsidence offers longer-term benefits by reducing the future accommodation space.
- The general cost of implementation of this scenario is about $17.1 billion, and the cost benefit for a 50-year life cycle is about $80 billion (see Table 18-6 for other life-cycle cost benefits and impacts).

19.4 CONCLUSION

Three significant and equivalent impacts are identified as a result of major flood or seismic events in the Delta. They are in-Delta losses, loss of transportation and utility services, and loss of water for export to out-of-Delta urban and agriculture users.

Although the transportation and water conveyance losses are self-defined, the in-Delta impacts include developments, businesses, population at risk, and bio-diverse habitats.

The preliminary risk reduction evaluation conducted in this study indicates that the trial scenarios will rank in the following order when compared on benefit-versus-cost valuations:

1) Isolated Conveyance Facility: Lowest cost for the highest benefit

2) Dual Conveyance: second lowest cost for the second highest benefit

3) Through-Delta Conveyance: Third lowest cost for the third highest benefit

4) Improved levees: Fourth lowest cost for the fourth highest benefit

A final observation of the initial trial scenario results suggests that more detailed evaluations should be made to assess the benefits and the costs. These evaluations seem important in light of the considerable expense required to achieve meaningful risk-reduction benefits.